# Detecting and Adjusting on Temporal Inhomogeneity in Chinese Mean Surface Air Temperature Dataset

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**Beijing 2003**

# The inhomogeneity in climatological series

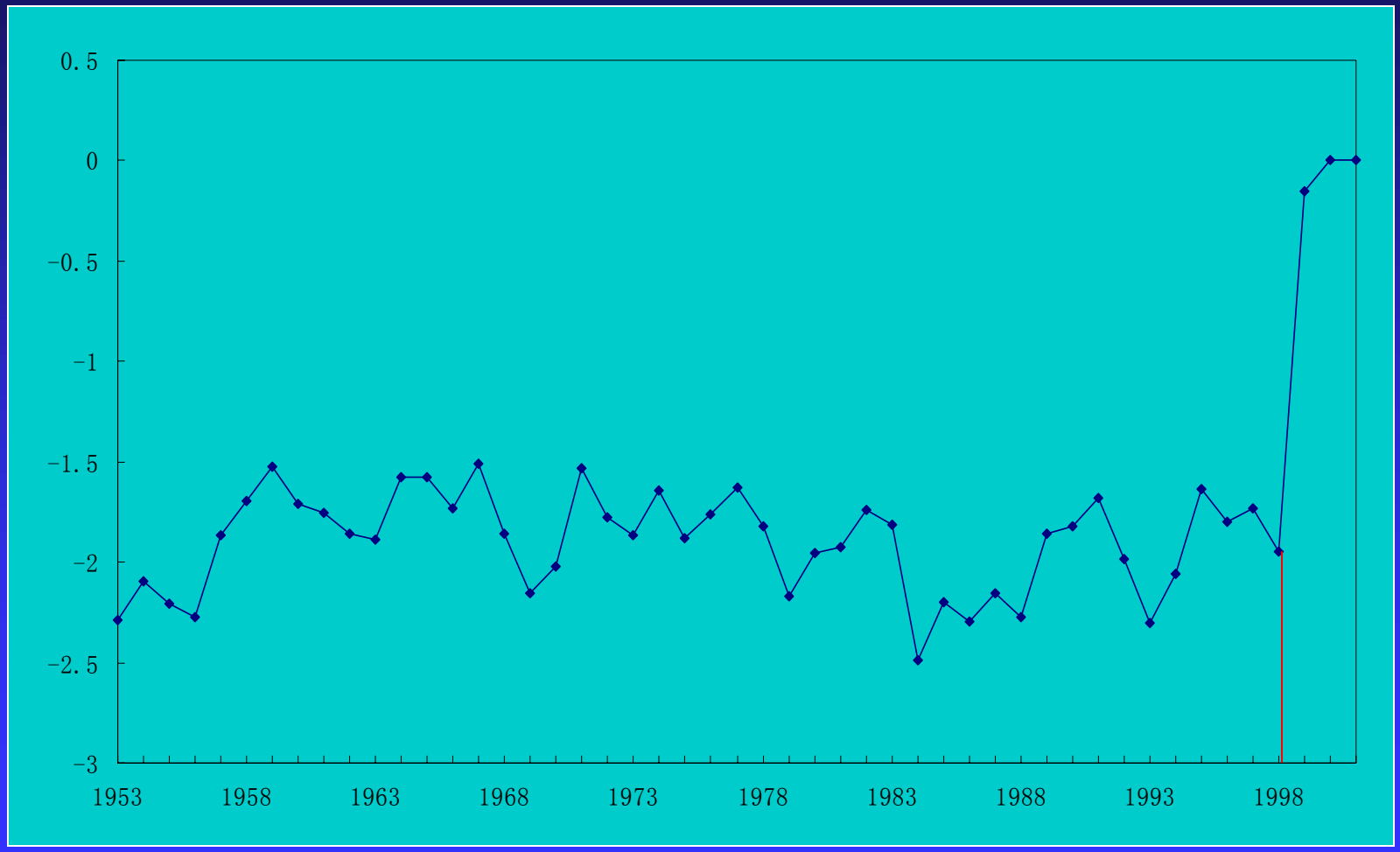
Climatological data series:

1、 real climatic change： real local climate change；

2、 apparent change： caused by many factors like instruments、observed times、relocations、environments and other factors.

- The latter changes are the main factors of temporal inhomogeneity in a time series.

# The embodiment of the inhomogeneities in a time series



# The procedure of inhomogeneity test and adjusting

- Find real local climatic change of a site;
- Compare the observed time series to the real climatic change;

**An abrupt changes in the difference series between the observed time series and reference series.**

**An obvious different trend between them**

- Adjust the observed time series

# The techniqures of detecting the discontinuities of time series—by Tom Peterson and Dave Easterling

- Direct methods:

1. Use of metadata
2. Side by side comparisons of instrument
3. Statistical studies of instrument changes

- Indirect methods

1. **Subjective methods:**

***Experienced climatologist,***

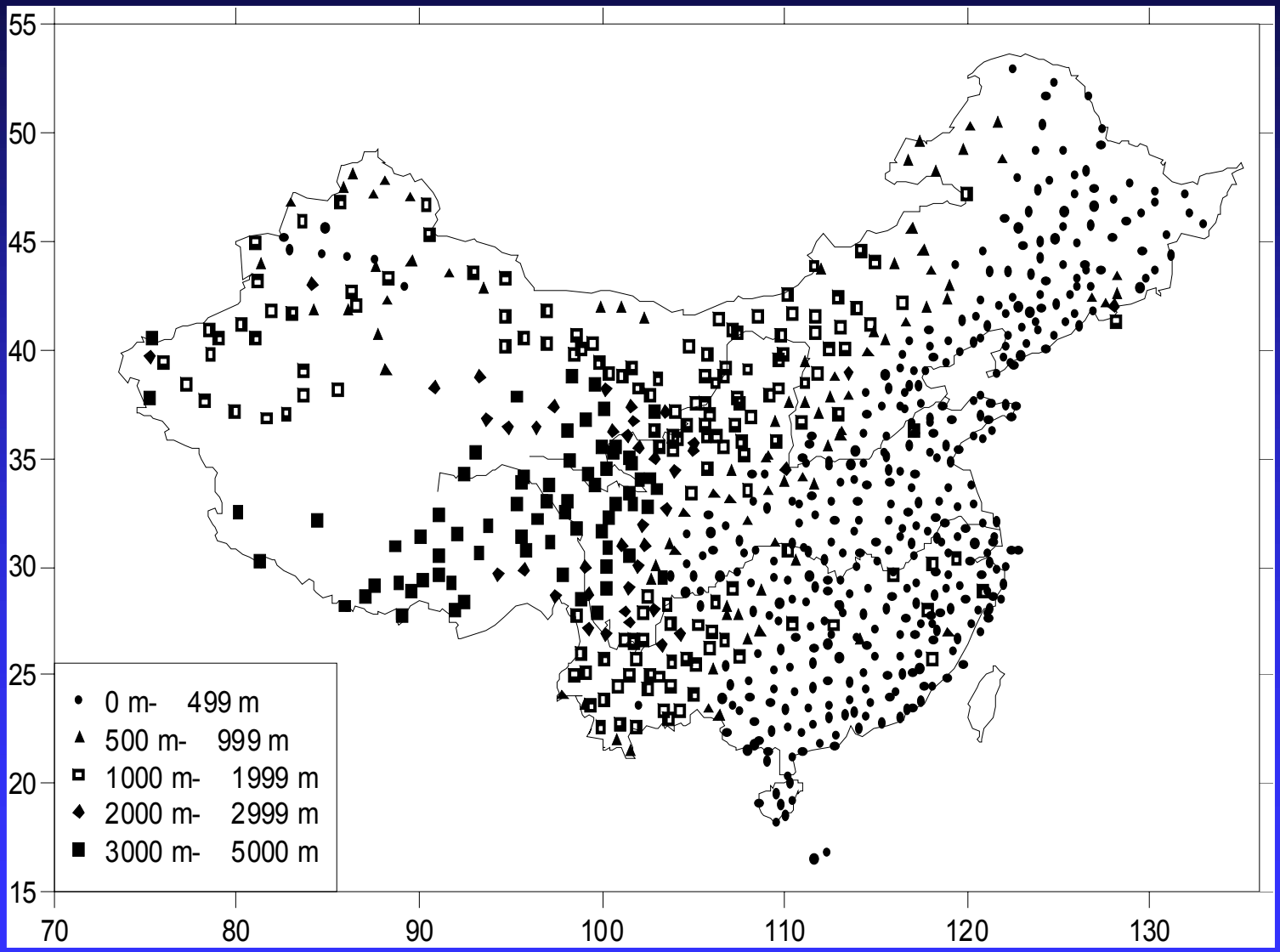
**double-mass analysis(1949)+CUSUM(cumulative sums)(1993) provide additional insights for a subjective assessment**

2. **Objective methods**

# Objective methods(model)

1. Potter's methods
2. SNHT
3. Multiple linear regression
4. Two-Phase regression
5. Rank order change point
6. Craddock test
7. T-test
8. Caussinus-Metstre technique.
9. MASH

# The distribution of the stations in China



# The summarization of the study on the homogeneity of Chinese climatological series

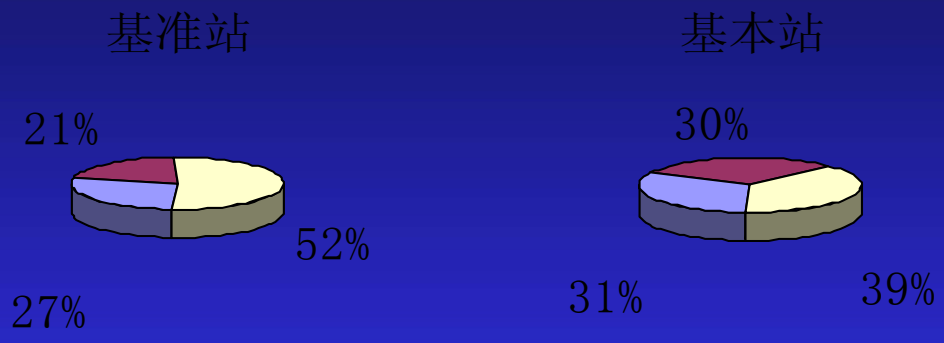
There are much work in which the homogeneity of surface air temperature, precipitation, annual wind speed and radiosonde data has been tested.(Liu and Sun, 1995, Song et al, 1995 , Zhai, 1997, Liu, 2000, Liu and Li, 2003).

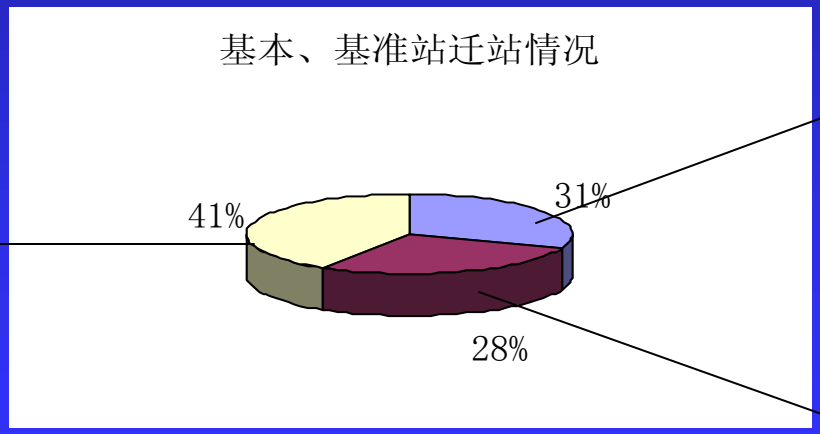
But few homogenized Chinese climatological dataset has been developed until recently.

Homogenization of climatological data has been introduced in "China National Climatic Change Plan 2001-2010" It is urgent to strengthen this kind of study.

# The metadata relevant to the homogeneity(1)

- Relocation of the stations




Relocated once

Relocated for more than 1 time

Never be relocated

# The metadata relevant to the homogeneity(2)

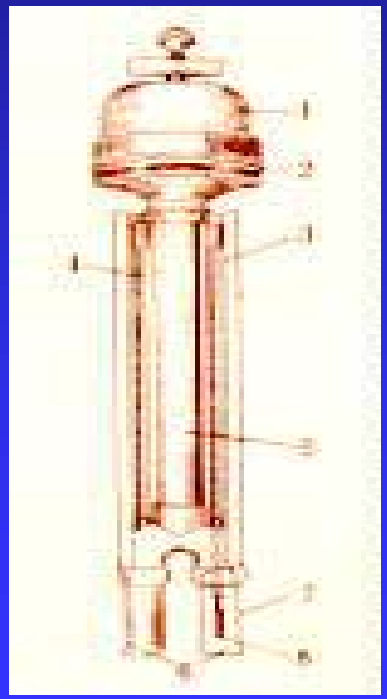
- **observed time change:**

**Before 1960：** 1, 7, 13, 19 or 7, 13, 19 －Local time;

**Since 1960：** 2, 8, 14, 20 or 8, 14, 20 －Beijing time.

- **Instrument:**

**Dry-bulb thermometer －Since 1951**



## Main issues we concern:

- Will the frequent relocations of Chinese meteorological stations lead to the discontinuities in the temperature series?

- Will the observed time change in 1960 have much effect on the homogeneity of the time series?

# The main outlines of inhomogeneity detecting:

- Collecting  metadata as detailed as possible ;
- Showing sufficient respect to the observation;
- Taking the local climatic change into consideration;
- Seeking the combination of objective and subjective methods of detecting and adjusting the inhomogeneous temperature series.

# E－P techniques:

- Creation of reference time series:

Peterson, T.C. and D.R. Easterling, 1994: Creation of homogeneous composite climatological reference series, Int. J. Climatol., 14, 671-679.

- Testing and adjusting the time series

Easterling, D.R. and T.C. Peterson, 1995: A new method for detecting and adjusting for undocumented discontinuities in climatological time series, Int. J. Climatol., 15, 369-377.

# Highlights of the E—P techniques

- This methodology is an automated, objective, and repeatable discontinuity identification and adjustment routine;
- It is very robust,  it can detect nearly all the discontinuities only by objective methods. To temperature , it is proved to be helpful. So if the metadata is not completed or even they cannot be obtained at all,  the technique will be suitable. (GHCN)
- In our study, the metadata is not completed, so we adopt the E—P method.

# Practical problems in inhomogeneity test

- The E—P technique is very sensitive and robust, some of the discontinuities were proved to be wrong or not existing at all, further studies of the judging results are necessary;
- Discontinuities appearing in the 5$^{th}$ year of the beginning (or ending) year deserves more attention (E-P technique requires segment of series more than 5 points) ;
- Influence of the same change in a large area (such as the change of calculating method and observational habits) is not easily detected.

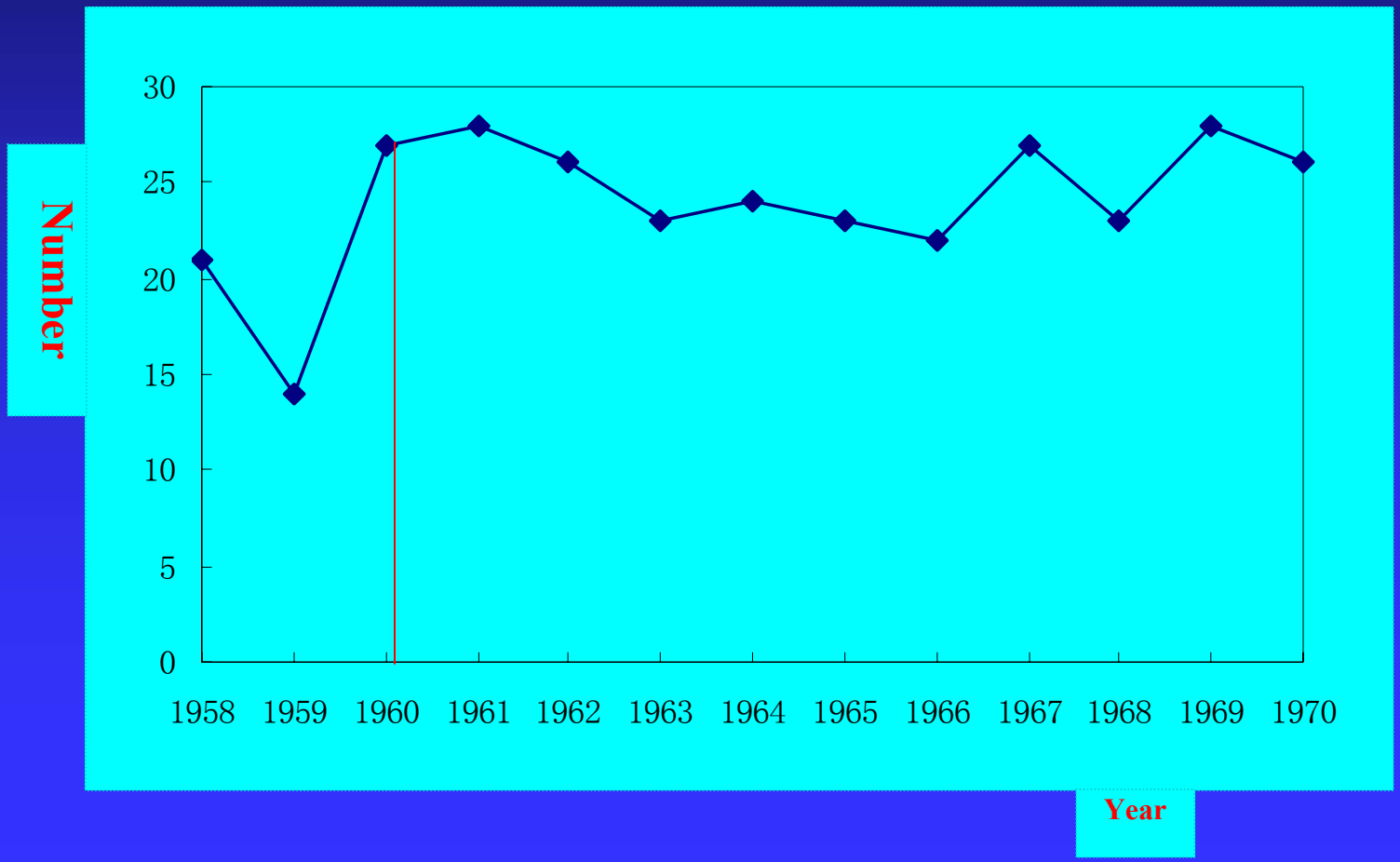
# The scheme designs

- **Test 1**: The techniques are used to test the inhomegeneity of the temperature time series without change anything to all the potential discontinuities, and then to further check the stations history records to check the rationality of the discontinuities;
- **Test 2**: The techniques are used to test the inhomegeneity of the ***substitutional*** temperature (created by the monthly average of the maximum and minimum temperatures) time series but nothing else changed, to get some additional discontinuities. If the discontinuities are same with the ones in test 1, they are taken as the reasonable ones to fill up the insufficiency of the metadata;
- **Test 3**: The ***substitutional*** temperature time series is used to create the reference time series for each candidate station, and test the temperature time series' inhomogeneity. This test will help us to minimize the effects of the changes of calculate-mean methods at the same year (i. e., in 1960). If there are many discontinuities in 1960, it can be concluded that the changes impose much effect on the homogeneity of Chinese surface air temperature series. Otherwise, the effects are deemed as less important.

# Result Analysis 1

**Test 3 :**

- **The potential discontinuities tested in test 3 during 1958－1970**



# Result Analysis 2

## The number of main discontinuities:

- By relocation/ operation change:197 (test 1)
- By substitutional data: 115 (test 1, test 2)
- Compared with threshold: 106(test 1)

- Total: 418

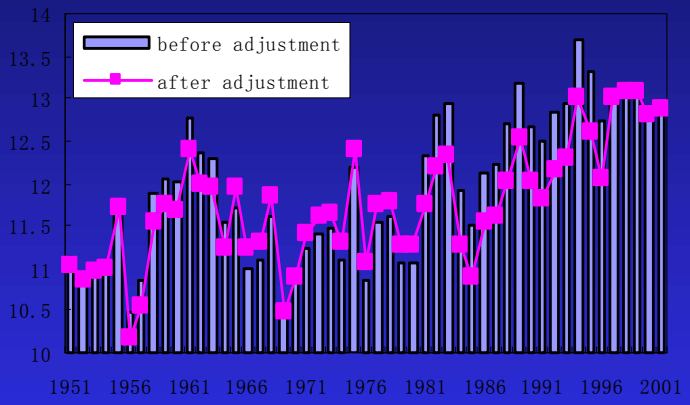
# Adjustment of inhomogeneous discontinuities

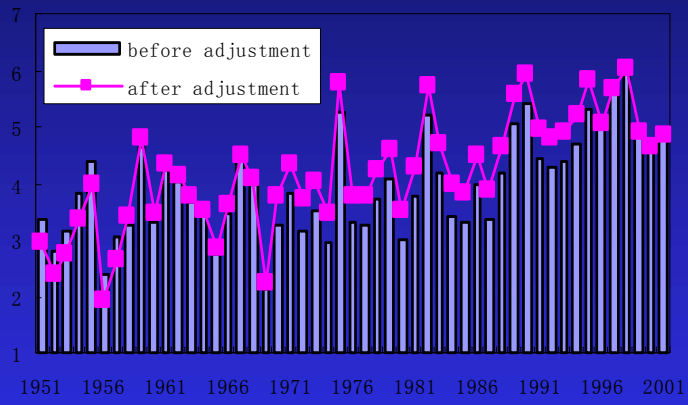
- The inhomogeneity adjustment is the process of gradually removal of the detected discontinuities to ensure the time series becomes "relatively homogeneous".

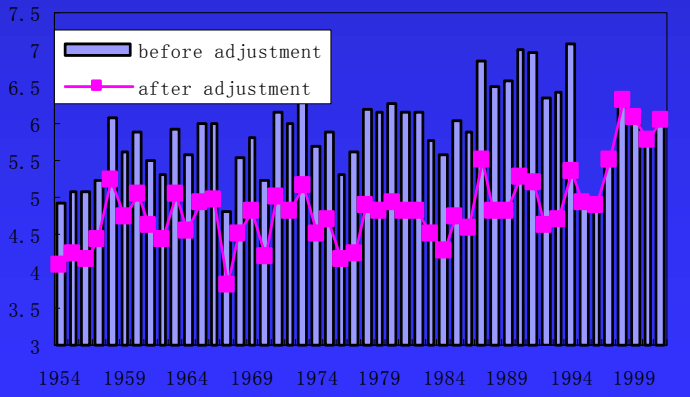
- Here several study principles are strictly followed to ensure every point adjusted is real discontinuities, those points with uncertainty are remained. At the same time the same series is adjusted as least as possible in order to avoid introducing man-made inhomogeneities.

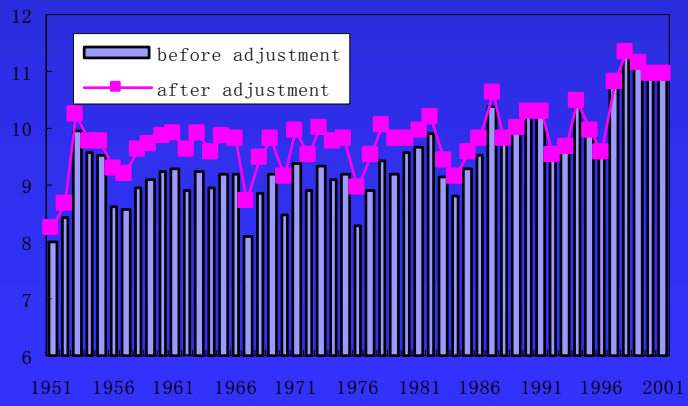
# Comparison of Temperature time Series Before and After Adjustments

- Annual surface air temperature series of Beijing (top left), Ha'erbing (top right). Xining (bottom left) and Lanzhou (bottom right) before and after adjustment



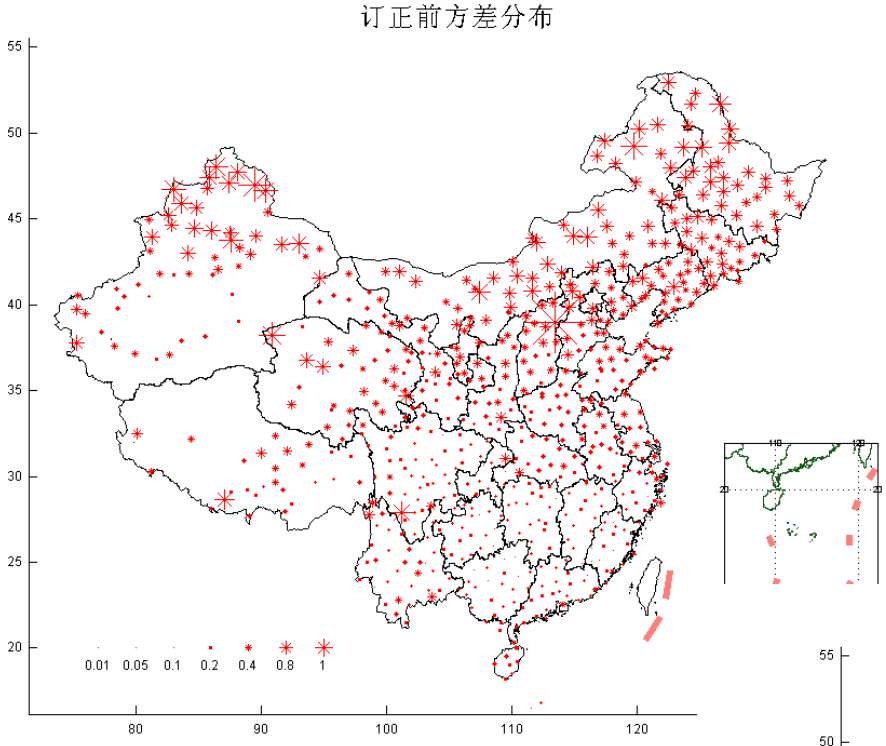



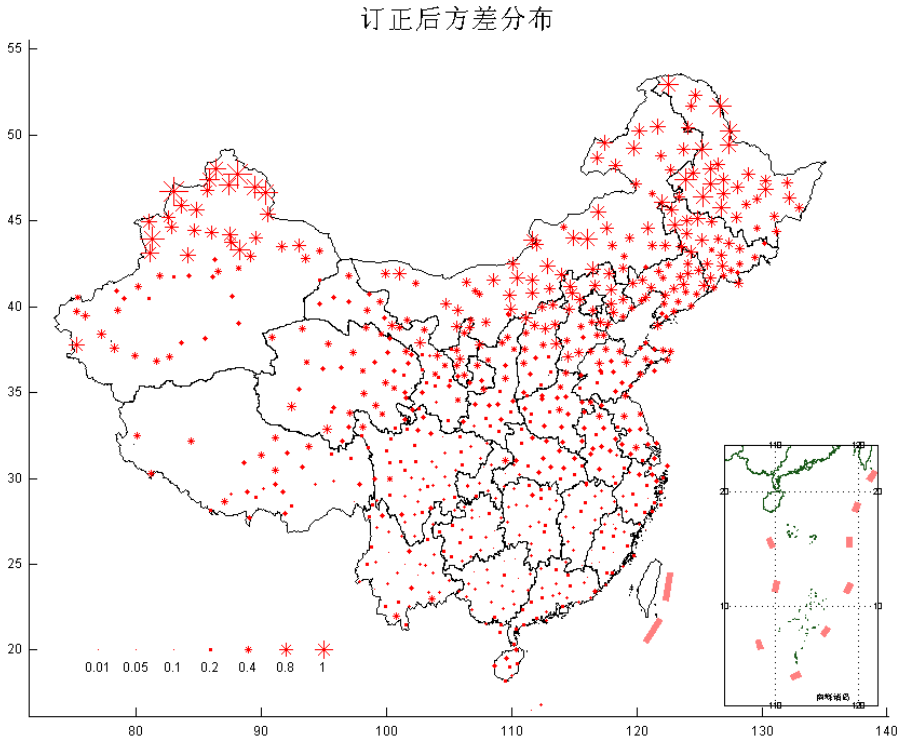



# the comparison between the station files and the discontinuities of the 4 stations

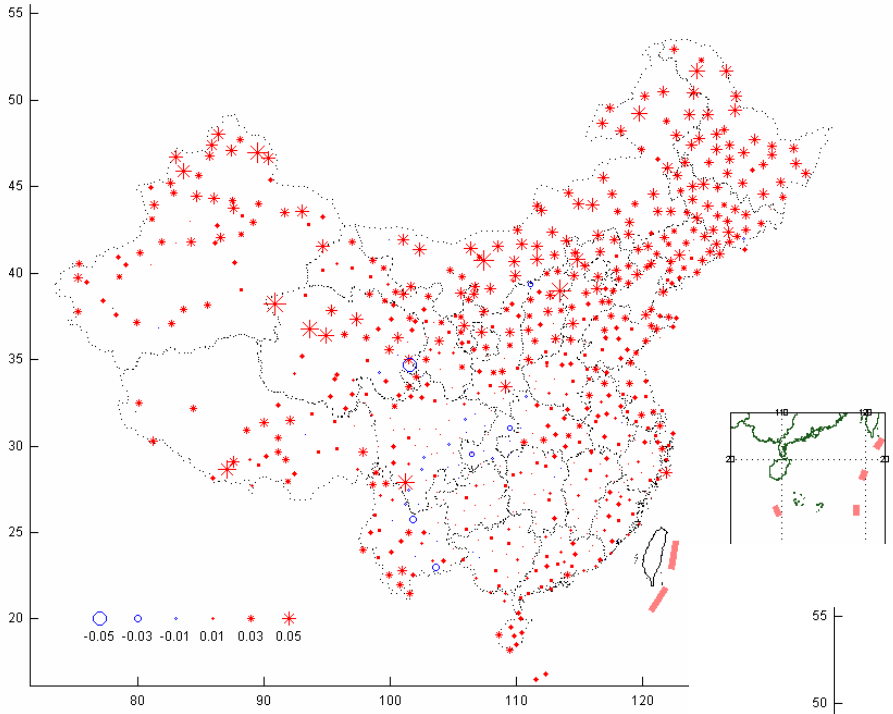
- Beijing
- Discontinuities 1955，1964，1970，1980，1996
- Relocation years 1953，1965，1969，1970，1981，**1997**
- Ha'erbin
- Discontinuities 1957，1969，1995
- Relocation years 1958，1971，1981，**1995**
- Xining
- Discontinuities 1963，1987，1994
- Relocation years 1957，1958，1959，1969，1974，1981，**1995**
- Lanzhou
- Discontinuities 1955，1979，1987, 1995
- Relocation years 1956，1963，1967，1975，1988，**1996**



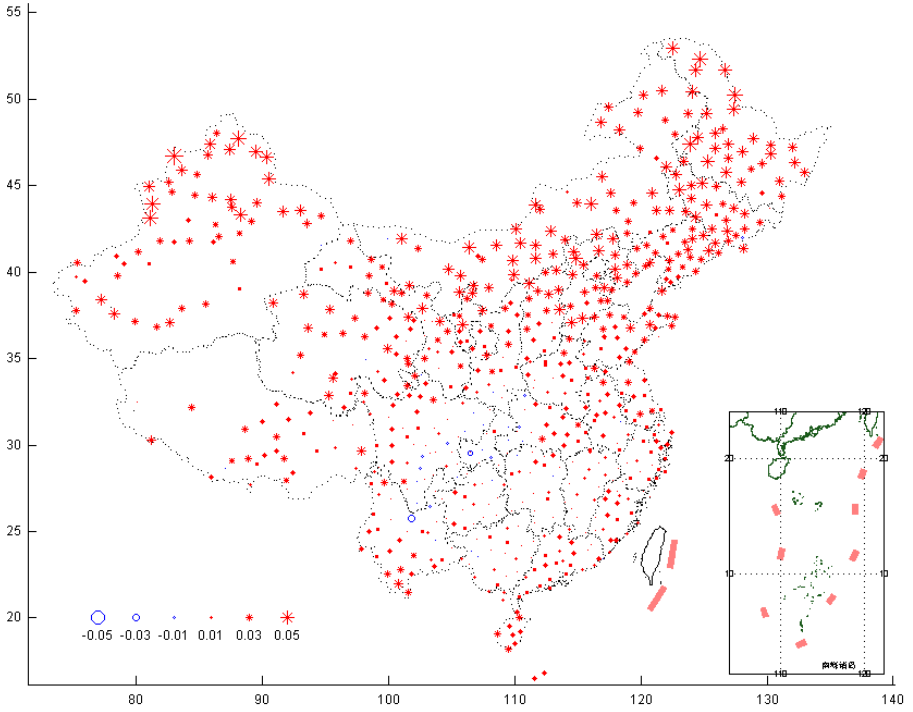

**The variance distribution of the annual temperature of before (top) and after (bottom) the adjustment (unit: (° C)$^2$).**



订正前的趋势分布

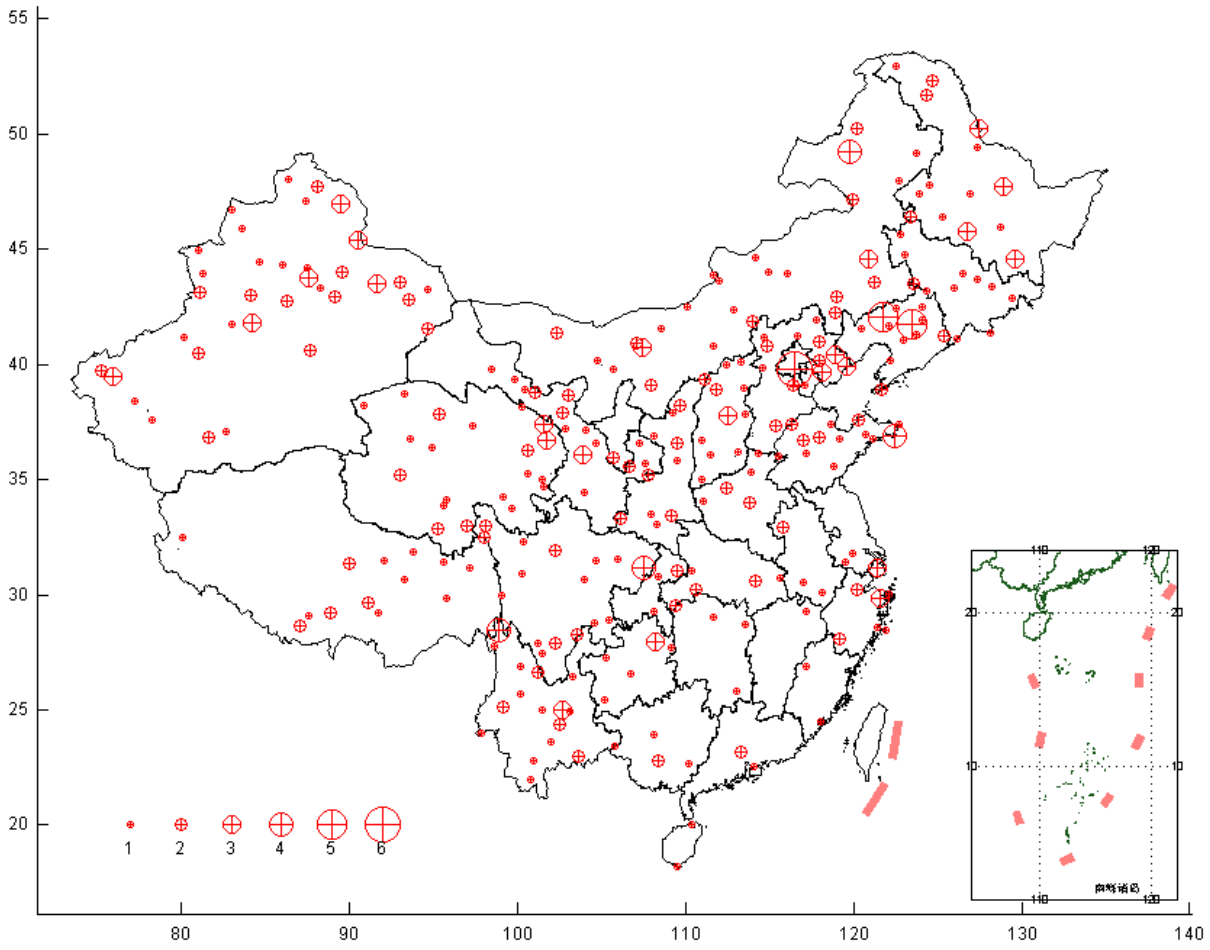



订正后的趋势分布




**The trend distribution of the annual temperature of before (top) and after (bottom) the adjustment (unit: (° C)$^2$).**

# The number of the main discontinuities in the period of 1951-2001



# Acknowledgment


- **The authors would like to thank the following persons: Tom Peterson, Dave Easterling, Dr Byron Gleason of National Climatic Data Center, NOAA, who provided much convenience (including the E－P softwares) and some helpful discussions to the job;**
- **Dr Lucie Vincent of Canada meteorology service provided some of the testing software kindly; and many experts of National Meteorological Center of CMA advanced many constructive ideas, and many support on observation data series and metadata.**
- **The research was supported by the special foundation project of Ministry of Science and Technology of PRC (No. 2001DEA30029-01-03) and "10th Five Years' Project"(No. 2001BA611B-01).**

# Thank you !